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Commodity Treatments:

Responses of Tomatoes and Green Bell Peppers to Fumigation With Methyl Bromide or Ethylene Dibromide

Abstract

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Fumigation of tomatoes with methyl bromide (MB) at dosages that might be used for control of the Mediterranean fruit fly (*Ceratitis capitata* Wied.) slows the rate of ripening of mature-green fruit by about 20 percent and slightly increases their susceptibility to decay. Splotchy ripening occurred in only one cultivar treated at 32°C.

Inorganic bromide residues in tomatoes were less than the legal tolerance of 20 parts per million, even at the maximum dosage of 48 g MB/m^3.

Green bell peppers were severely injured when fumigated with MB at a dosage effective against the Mediterranean fruit fly. Thus, MB is not a suitable fumigant for green peppers.

Fumigation of green bell peppers with ethylene dibromide (EDB) increased the incidence of decay and induced slight surface pitting. However, at the dosage used, the defects induced by EDB are not serious enough to preclude the use of EDB as a fumigant for green peppers to meet quarantine requirements.

At a dosage of 8 g EDB/m^3, the inorganic bromide residue was less than 25 p/m.

Keywords: Tomato, bell pepper, capsicum, fumigation, phytotoxicity, methyl bromide, ethylene dibromide, residues, sorption, ripening, injury, quarantine treatments, commodity treatments, storage, decay

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Commodity Treatments: Responses of Tomatoes and Green Bell Peppers to Fumigation with Methyl Bromide or Ethylene Dibromide

By W. J. Lipton, J. S. Tebbets, G. H. Spitler, and P. L. Hartsell[1]

Introduction

Tomato (*Lycopersicon esculentum* Mill.) and green bell pepper (*Capsicum annuum* L.) fruits are presumed to be potential hosts for the Mediterranean fruit fly (*Ceratitis capitata* Wied.) (*2*).[2] Since this insect is subject to quarantine within the United States and by foreign countries, its potential hosts must be disinfested before they can be shipped out of a quarantined area (*15*, sec. IV, p. 17-18). Fumigation with certain chemicals is one method of achieving such disinfestation; however, fumigation can be utilized only if the treatment has no, or only minor, adverse effects on the host and if residues left by effective treatments are within legal tolerances.

This publication provides information on the response of harvested tomatoes to fumigation with methyl bromide (MB) and green bell peppers to fumigation with MB or ethylene dibromide (EDB).

Tomatoes

Introduction

The effects of fumigation with MB on tomato fruits have been investigated periodically for over 40 years (*1, 6, 7, 9, 10, 13*). Generally, although not invariably, MB at concentrations of 32 g/m³ (2.0 lb/1,000 ft³) or above slows down the rate of ripening of initially mature-green fruit and leads to increased decay in lots that are predisposed to decay. Other effects of MB-induced injury are pitting and blotchy ripening (*13*).

There appears to have been little difference in the response of various tomato cultivars to MB; however, this lack of difference cannot be assumed for all types of fruits because in other commodities, such as nectarines and plums (*5*), cultivars differed substantially in their reaction to fumigation with MB. Consequently, we investigated the response of tomato cultivars currently grown in California to fumigation with various dosages of MB.

Methods and Materials

Fumigation

Tomatoes of the cultivars 'Castlemart' (two tests), 'Jackpot', and 'Royal Flush' (two tests) were obtained during the summer of 1979 from the Hollister, Huron, Patterson, and Le Grande areas of California. The tomatoes were harvested, waxed and packed commercially, and then transported to Fresno for treatment.

All fumigations were conducted at normal atmospheric pressure (NAP) in 0.24 m³ (8.4 ft³) steel chambers. Each chamber was equipped with an air circulation fan that operated throughout each fumigation. Previous tests (unpublished data) had shown that loss of MB due to sorption by the empty chamber was only 1.0 percent ± 0.3 percent after 4 hr.

Before treatment, all cartons of tomatoes, including check lots, were held 18 to 22 hr in controlled temperature rooms to allow the fruit to reach the desired temperature. The lots to be treated were then fumigated with MB for 3.5 hr as follows: 48 g/m³ at 16°C, 32 g/m³ at 24°, or 24 g/m³ at 32°, all ± 2° (3.0, 2.0, or 1.5 lb/1,000 ft³, at 61°F, 75°, or 90°, all ± 3.5°). These treatments were similar to those used by Cotton (*4*). The controls were held between 21° and 24°C (70° and 75°F) while the others were fumigated. We determined MB concentrations by means of a gas chromatograph equipped with a flame ionization detector. Samples of fumigant were taken 0, 0.25, 0.5, 1.5 and 3.5 hr after the start of fumigation. The load factor (v/v) for all fumigations was 58 percent to 62 percent. Table 1 shows MB concentrations, concentration x time products (C x T), and percent sorption for the three treatments. The C x T products are expressed in g • hr/m³ and are similar to Monro's derivation (*8*): Theoretical C x T (g • hr/m³) = C_D (g/m³) x t (hr). The actual C x T product is calculated from the fumigant concentrations at various sampling times, that is, the area under the concentration curve in g • hr/m³. Sorption (percent) = $[(C_D = C_R)/C_D] \times 100$. For the above calculation, C_D = desired concentration or dosage of fumigant, t = exposure time, and C_R = concentration remaining at the end of t.

After treatment, the chambers were aerated 2 hours at a flow rate of 0.054 m³/minute (1.9 ft³/min). Thus, the chamber was flushed once every 5 min. When the chambers were opened, we took samples of fruit for residue analysis. Inorganic bromide residue was deter-

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[1] Lipton is a plant physiologist, Market Quality and Transportation Research Laboratory, P.O. Box 8143, Fresno, Calif. 93747; Tebbets, Spitler, and Hartsell are biological technician, research entomologist, and physical science technician, respectively, Stored Product Insects Research Laboratory, 5578 Air Terminal Drive, Fresno, Calif. 93727.

[2] Italic numbers in parentheses refer to Literature Cited, p. 8.

Table 1—Dosage, methyl bromide concentrations, and percent sorption for fumigation of tomatoes[1]

Treatment		Concentration at indicated hours from start of fumigation					Product (C x T)		
Dosage[2]	Temperature	0	0.25	0.5	1.5	3.5	Theoretical[3]	Actual[4]	Sorption[5]
G/m³	*°C*	*G/m³*					*G • hr/m³*		*Percent*
48	16 ± 2	52	46	43	37	29	168	130	38
32	24 ± 2	37	32	30	25	20	112	89	38
[illegible]	32 ± 2	28	25	23	19	16	84	69	33

[1]The fumigation lasted 3.5 hr; the load factor was 58 to 62 percent.

[2]Theoretical concentrations.

[3]Dosage (or Theoretical Concentration) x time of exposure, see text.

[4]Area under actual concentration curve, see text.

[5]Based on dosage and final (3.5 hr) concentration. Uncorrected, that is, values for empty chamber sorption not subtracted.

mined by the method described by Schrader et al. (*12*), as modified by Hartsell.[3]

Storage

Upon completion of aeration, the tomatoes were categorized according to their degree of ripeness, which ranged from mature-green through red (*14*). Then, the tomatoes, two boxes (replications) per treatment, were stored 13 to 15 days at 15°C ± 0.5° (59°F ± 1°). This time-temperature combination simulates transit conditions to distant markets. At this evaluation (examination I), we again categorized the fruit by degree of ripeness and examined it for symptoms of acute MB injury and decay. Any decayed fruits and those that were red were discarded at this time. After this examination, we returned the fruits to the boxes and held them for 2 or 3 days at 20°C ± 0.5° (68°F ± 1°) to simulate a wholesale and/or retail marketing period and to permit further ripening. At the end of this period (examination II), the tomatoes were evaluated as previously.

For four of the six tests, rates of ripening were determined by calculating the mean degree of ripeness (R) initially and at examination I as follows:

$$R = (n_1 \times 1 + n_2 \times 2 \ldots + n_6 \times 6)/N$$

where:

n = number of fruit in each ripeness category (*14*)

1, 2...6 = numerical value assigned to each ripeness category from green to red

N = total number of fruit in lot (between about 60 and 100, depending on size of fruit).

[3]Hartsell, P. L. Total and inorganic bromide residues on commodities fumigated with methyl bromide. Method PR-6e-64, Revised Dec. 1965. Unpublished method, Stored Product Insects Research Laboratory, U.S. Department of Agriculture, Agricultural Research Service, Fresno, Calif. 93727.

Then, the mean change in degree ripeness (ΔR) per day was:

$$\Delta R = (RI - Ri)/d$$

where:

RI = ripeness at examination I

Ri = ripeness initially

d = number of days in storage

Similar calculations cannot be made for the interval between examination I and examination II unless individual fruits are tracked since fruit that was relatively unripe, for example, turning, at examination I would change more during holding at 20°C (68°F) than fruit that was already pink. For these four tests, we also determined the percentage of fruit that was red at each examination.

Quantitative data were tested by analysis of variance, and means were compared with Duncan's multiple range test at the 5-percent level of significance. Since the same tomatoes were evaluated at both examinations, the respective data were analyzed separately.

Results

Effects of Methyl Bromide

Acute Injury—The symptoms of acute MB injury we observed, splotchy ripening and yellowing, were indistinguishable from such discolorations induced by a number of other factors that interfere with the normal ripening of tomatoes. Splotchy ripening and/or yellow areas on the normally red surfaces, however, were symptoms of MB injury in one test with 'Castlemart' tomatoes that had been treated 3.5 hr at 32°C (90°F) with 24 g MB/m³ (1.5 lb/1,000 ft³). Splotchy ripening affected about half of the fruit, but the yellowing affected less than 10 percent. None of the other treatments elicited any acute injury on any of the cultivars tested.

Effects on Ripening—Fumigation with MB slowed the rate of ripening of tomatoes stored at 15°C (59°F) by about 20 percent for all cultivars, regardless of treatment (table 2). The slowing of the rate of ripening, as would be expected, was reflected in the proportion of tomatoes that had reached the red-ripe stage at each examination. After storage at 15°C (59°F), only about one-half as many treated as control fruit were ripe. However, during the additional 2 to 3 days at 20°C (68°F), the gap between treated and control fruit narrowed to about 10 percent. Nevertheless, the difference between the treated and control fruits was still statistically significant. Again, all cultivars responded similarly to all treatments.

Table 2—Rate of ripening and percent of tomato fruits that had reached the red ripe stage or that showed decay after 13 to 15 days of storage at 15°C (59°F) and subsequent ripening for 2 or 3 days at 20°C (68°F)

Temperature during fumigation	Methyl bromide concentration		Rate of ripening	Red ripe fruit: After storage	Red ripe fruit: After ripening	Decayed fruit: After storage	Decayed fruit: After ripening
°C	*G/m³*	*Lb/1,000 ft³*	*Units/day*[1]	*Percent*[1]	*Percent*[1]	*Percent*[2]	*Percent*[2]
16	0	0	0.23	38	85	5.4	5.5
	48	3	0.18	16	75	5.6	6.4
24	0	0	0.25	42	89	2.3	2.3
	32	2	0.20	23	79	3.7	4.3
32	0	0	0.25	39	91	3.3	3.7
	24	1.5	0.20	19	82	5.6	6.5

[1]The values in each pair of data differ at the 5-percent level of significance. See text for derivation of calculations for rate of ripening.

[2]Only the pair of data for 32°C differs at the 5-percent level of significance.

Effects on Incidence of Decay—MB fumigation at 16°C or 24° (61°F or 75°) had no statistically significant effect on the incidence of decay, although the incidence was slightly and consistently higher in treated (48 or 32 g MB/m³, 3.0 or 2.0 lb/1,000 ft³) lots. When the tomatoes were treated at 32°C (90°F) with 24 g MB/m³ (1.5 lb/1,000 ft³), more decay developed in the treated than in the control lots, whether based on examination after storage at 15°C (59°F) or after ripening at 20°C (68°F) (table 2). In a second series of two tests, the results followed the same pattern as those noted above.

Residue of Methyl Bromide

The Environmental Protection Agency established a tolerance of 20 parts per million (p/m) MB and a maximum dosage and exposure limitation of 48 g/m³ (3.0 lb/1,000 ft³) for 4 hr for fumigation of tomatoes with MB (*16*). The inorganic bromide residues found in tomatoes for the three treatments of this study ranged from 9 to 17 p/m (table 3); thus, all were within the legal tolerance.

Table 3—Inorganic bromide residues in tomatoes treated with methyl bromide for 3.5 hr and various dosages and temperatures

Dosage	Temperature	Inorganic bromide residues[1]	
G/m³	*°C*	*Sample No.*	*P/m*
48	16 ± 2	1	17
		2	10
		3	11
		4	12
Mean			12
32	24 ± 2	1	10
		2	10
		3	9
		4	11
Mean			10
24	32 ± 2	1	14
		2	9
		3	13
		4	9
Mean			11

[1]The residue in the control samples (all less than 2 p/m) was not subtracted from these values.

Discussion and Conclusions

Our results with cultivars of tomatoes currently grown in California parallel those with cultivars grown here 30 or more years ago (*7, 10*) and they parallel those with various cultivars grown in Hawaii (*1, 6*) and in Florida (*13*), when similar treatments are compared. In general, acute injury attributable to MB developed only when the concentration exceeded 32 g/m³ (2.0 lb/1,000 ft³) during a 3.5-hr treatment at 21°C (70°F). At 16°C (61°F), even 48 g MB/m³ (3.0 lb/1,000 ft³) induced no acute damage; however, when the tomatoes were treated at 32°C (90°F), even 24 g MB/m³ (1.5 lb/1,000 ft³) applied for 3.5 hr definitely was harmful.

Fumigation with MB characteristically slows the rate of ripening of tomatoes. All cultivars, those used by us and those used by others (*1, 6, 7, 10, 13*), reacted similarly.

While MB slowed the rate of ripening, it did permit treated tomatoes to eventually reach normal red color as long as the dose was not acutely phytotoxic.

Tomatoes with a high decay potential should not be fumigated with MB because the treatment sometimes increases susceptibility of the fruit to decay. Although this effect is not consistently observed, it is important in lots of tomatoes that have cracks or that have been physically injured (*1*) or in lots that have suffered chilling injury before or after harvest (*9*). Consequently, no attempt should be made to ship tomatoes with a high decay potential out of a quarantined area.

The consistency of the results reported here with those reported in the literature suggests that diverse cultivars of tomatoes react similarly to fumigation with MB. Thus, a continued, extensive program of evaluation should not be necessary as new cultivars are released.

Peppers

Introduction

The response of bell peppers to fumigation with MB or EDB was investigated by Pratt et al. (*10*) with an unspecified cultivar. The authors, however, were ambivalent in their conclusion regarding treatment with MB. In one table, they stated that peppers tolerate the "approved" treatment of 32 g MB/m³ (2.0 lb/1,000 ft³) for 4 hr when treated at 21°C (70°F); in another table the opposite is stated, but the discrepancy is not explained. Symptoms of injury were surface pitting of the pod and development of decay on the calyx and stem.

The results of Pratt et al. (*10*) with EDB were more clearcut: All dosages, which ranged from 8 g/m³ for 2 hr to 32 g/m³ for 2 hr (0.5 to 2.0 lb/1,000 ft³) and were applied at 20°C (68°F), were harmful. The symptoms of injury for EDB presumably were the same as for MB since they were not described separately.

Since the above results were not suitable as a basis for recommendations of fumigation schedules, we fumigated bell peppers with MB and EDB to determine whether these chemicals could be used to disinfest this vegetable.

Methods and Materials

Fumigation

Methyl Bromide—We fumigated the bell peppers with MB at NAP in wooden chambers with a volume of 3.1 m³ (110 ft³); air circulated continuously during the exposure period. The load factor (v/v) for all tests was less than 5 percent. Hence, the concentration curves and subsequent sorption (table 4) were not appreciably different from those obtained during trials with empty chambers (unpublished data).

Table 4—Dosage, concentrations, and percent sorption for fumigation of bell peppers[1]

Treatment			Concentration at indicated hours from start of fumigation					Product (C x T)		
Dosage[2]	Temperature	Aeration	0	0.25	0.5	1.0	3.0[3]	Theoretical[4]	Actual[5]	Sorption[6]
G/m³	*°C*	*Hr*	*G/m³*					*G • hr/m³*		*Percent*
Methyl bromide:										
A										
48	[7]	3	46	44	43	42	39	144	124	19
40	24 ± 2	3	38	—	36	35	31	120	103	22
32	21 ± 2	3	31	—	30	30	27	96	87	16
B										
32	21 ± 1	2	30	—	29	29	27	64	57	16
Ethylene dibromide:										
C										
8	15 or 21 ± 2	2	6.5	—	5.5	4.9	3.7	16	10	54

[1]The load factor was less than 5 percent.

[2]Theoretical concentration.

[3]Concentrations measured after 2.0 hr for B and C.

[4]Dosage (or Theoretical Concentration) x time of exposure, see text.

[5]Area under actual concentration curve, see text.

[6]Based on dosage and final (3.0 or 2.0 hr) concentration. Uncorrected, that is, for values for empty chamber sorption not subtracted.

[7]Tests conducted at 21°C, 24°, or 27° ± 2°; data combined since results were same at all temperatures.

Note: dashes indicate no data.

The peppers were preconditioned to selected treatment temperatures as described for tomatoes. 'Yolo Wonder' bell peppers for all tests were grown in Fresno County and were packed commercially after the customary waxing done in California.

In preliminary tests with an unspecified cultivar, we fumigated MB at dosages of 32 g/m^3 at 21°C, 40 g/m^3 at 24°, and 48 g/m^3 at 21°, 24°, or 27° all ± 2° (2.0, 2.5 or 3.0 lb/1,000 ft^3 at 70°F, 75°, or 80° all ± 3.5°) (table 4 *A*). All treatments lasted 3 hr. Since all of these dosages were highly phytotoxic, we then treated with 32 g MB/m^3 (2.0 lb/1,000 ft ^{3}) applied for only 2 hr at 21°C (70°F) (table 4 *B*). Posttreatment aeration was 2 hr for all tests. After aeration, inorganic bromide residue was determined only on the latter treatment and by the same method used for tomatoes.

Ethylene Dibromide—EDB fumigation of peppers was conducted in the same manner and in the same steel chambers described for MB on tomatoes. The load factor (v/v) for all tests was 20 to 24 percent. Empty chamber sorption of EDB at 8 g/m^3 (0.5 lb/1,000 ft^3) for 2 hr was 14 percent ± 2 percent. Pretreatment temperature conditioning was similar to that described for tomatoes.

The peppers were fumigated with EDB at 8 g/m^3 (0.5 lb/1,000 ft^3) for 2 hr at 21°C ± 2° (70°F ± 3.5°) (table 4 *C*), which was the same dosage that Pratt et al. (*10*) found to be injurious. Concentrations of EDB were determined by the same method we used for MB, but we sampled the fumigant at 0, 0.5, 1, and 2 hr after the start of fumigation. The peppers were aerated 2 hr and then were sampled for residue. In the second test, we used the same dosage and exposure time, but treated at 15°C (59°F) and aerated for 2, 3, or 4 hr subsequent to fumigation. Residue samples were taken only after 2 hr of aeration. Inorganic bromide residue was determined by the same method used for tomatoes. Both of these tests were conducted with 'Yolo Wonder' peppers harvested near Fresno in August or September 1980. The peppers were grown and packed commercially and were waxed as customary.

Storage

After the peppers were aerated, they were stored for 8 to 10 days at 7.5°C or 10° (45°F or 50°), at which time one-half (at least 25) were examined. When warranted by the condition of the peppers, the other half was held for an additional 3 days at 15°C (59°F). At each examination, we evaluated the peppers for degree of firmness, incidence of decay, external symptoms of acute injury due to MB or EDB, color of the seeds and other internal symptoms of injury, and for color changes associated with ripening. Finally, each lot was given a rating for overall quality, in which 9 = excellent, essentially free of defects, and 1 = inedible.

Statistical evaluation of the data was not necessary because the results were unambiguous.

Results

Effects of Methyl Bromide

In the preliminary tests, all MB treatments induced [illegible] injury of peppers. The symptoms consisted of an objectionable softening of the tissue, a brown discoloration of the placenta near the stem end, an accumulation of free liquid in the cavity of the pod (fig. 1), a tan to brown darkening of the seeds (fig. 2), and a high incidence of decay, particularly of the calyx. None of these symptoms was evident on the day of fumigation, but all, other than decay, were evident after the peppers had been held 1 week at 7.5°C (45°F). The decay developed during subsequent holding for 2 or 3 days at 15°C (59°F).

In the more extensive test, 96 to 98 percent of peppers treated with 32 g MB/m^3 (3.0 lb/1,000 ft^3) for 2 hr at 21°C (70°F), developed decay of the stem, calyx, and/or pod during 9 days of storage at 10°C (50°F). In contrast, only 15 percent of the stems of the controls showed any decay, and none of the calyxes or pods was decayed. Seeds were tan to brown in two-thirds of the treated peppers, but only in one-fifth of the controls; free water had accumulated in three-fourths of the fumigated pods, but in none of the controls. A surface pitting (fig. 3), which resembles sheet pitting normally associated with chilling injury, was visible on one-fifth of the treated peppers and was absent on the controls. The discoloration of the placenta and extreme softening of the peppers evident in the preliminary tests were not evident in this later test.

The effect of the fumigation on ripening was not clear because only 11 percent of the control peppers had 10 percent or more of their surface yellow and only 6 percent of those treated were so affected. Even if this difference were consistent, it would be of no importance in view of the severe injury induced by MB.

We did not evaluate the firmness of the peppers because of the extensive decay development.

As a result of all the injuries induced by fumigation with MB, the treated pods were rated 1 or 2 (inedible) for overall quality, whereas the controls were still rated 8 (good to excellent) after the 9 days at 10°C (50°F). Due to the severe MB injury evident at the first examination, a second examination was omitted.

Residue of Methyl Bromide

The established tolerance for inorganic bromide residues in MB-treated bell peppers is 30 p/m (*17*). Inorganic bromide residues found in peppers treated with 32 g MB/m^3 at 21°C ± 2° (3.0 lb/1,000 ft^3 at 70°F ± 3.5°) for 2 hr ranged from 18 to 19 p/m, values that are well within the legal tolerance (table 5). However, the peppers were damaged by this treatment.

Figure 1—Pod on left shows methyl bromide-induced injuries on bell pepper. Note brown discoloration of placenta and of seeds and accumulation of liquid in pod. Same type of injury induced with 32, 40, or 48 g MB/m^3 (2.0, 2.5 or 3.0 lb/1,000 ft^3) applied for 3 hr at 24°C (75°F). Normal pod on right. Photographed after 7 days of storage at 7.5°C (45°F).

Figure 2—Browning of seeds of pepper (right) induced by methyl bromide at 32 g/m^3 applied for 3.5 hr at 24°C (2.0 lb/1,000 ft^3 at 75°F). Ethylene dibromide at 8 g/m^3 applied for 2 hr at 15°C (0.5 lb/1000 ft^3 at 59°F) did not discolor the seeds. Control on left. All photographed after 8 days of storage at 10°C (50°F).

Figure 3—Shallow pitting on bell pepper as induced by fumigation with 32 g MB/m³ (2.0 lb/1,000 ft³) for 2 hr at 21°C (70°F) followed by 9 days of storage at 10°C (50°F).

Table 5—Inorganic bromide residues in bell peppers treated for 2 hr with methyl bromide (MB) or ethylene dibromide (EDB) at various dosages and temperatures

Treatment	Temperature	Inorganic bromide residues[1]	
	°C	Sample No.	P/m
32 g MB/m³	21 ± 2	1	19
		2	18
		3	18
Mean			18
8 g EDB/m³	15 ± 2	1	22
		2	20
		3	19
Mean			20

[1]The residue in the control samples (all less than 2 p/m) was not subtracted from these values.

Effects of Ethylene Dibromide

In a test in which we evaluated the effect of tr[illegible] with 8 g EDB/m³ (0.5 lb/1,000 ft³) for 2 hr at [illegible]F) and then aerated for 2 hr, decay was so pervasiv[illegible] treated and control lots (incidence 99 and 100 pct, [illegible]tively) that fumigation effects, if any, were masked. W[illegible] not know why this lot of peppers was so severely decayed.

In the second test with EDB at the same dosage, but treated at 15°C (59°F), incidence of decay of the pods, the most serious type, was substantially higher in treated than in control lots after 8 days at 10°C (50°F). In the controls, decay was absent whereas it affected 28 percent of treated peppers. These results resemble those of Beever (*3*) who treated bell peppers with 12.4 g EDB/m³ (0.77 lb/1,000 ft³) at 20°C (68°F). In our tests, aeration for 3 or 4 hr about halved the incidence of decay as compared to 2 hr of aeration. After the additional 3 days at 15°C (59°F), the controls were still free from decay, whereas between 40 and 48 percent of those treated were decayed, regardless of duration of aeration. Thus, at the second examination, the effect of period of aeration was no longer important.

Decay of the calyx was minimal in all lots after 8 days at 10°C (50°F). After the additional 3 days at 15°C (59°F), 8 percent of the calyxes in the controls and between 24 and 40 percent of those from the treated lots showed decay. The increases in aeration time did not reduce the incidence of decay of the calyx.

Decay of the stems ranged from 24 to 32 percent of the controls and from 40 to 80 percent of those treated. However, neither duration of aeration nor of storage had any consistent effect.

Acute injury of peppers due to exposure to EDB closely resembled that induced by MB. Shallow pits were evident on 0 to 8 percent of the pods at the first examination and on 0 to 16 percent at the second one. The highest values were associated with the longest period of aeration; note, however, the injury was never more serious than "slight." Thus, these differences are not of practical importance.

EDB induced neither a discoloration of the seeds (fig. 2) and calyx nor an accumulation of free liquid in the pods. EDB had no effect on ripening during storage of the peppers at 10°C (50°F) but retarded it slightly at 15°C (59°F), a result that resembles effects observed by other workers with tomatoes (*11*).

The overall quality of the controls was excellent (rating 9) and that of all treated lots was good to excellent (rated 7 or 8) after the 8 days at 10°C (50°F). During the additional 3 days at 15°C (59°F), all ratings decreased by one unit, with only minor differences being evident among the lots aerated for 2, 3, or 4 hr. Thus, all lots of peppers, regardless of EDB treatment, were still considered salable at this time.

Residue of Ethylene Dibromide

To date, there is no approved treatment of bell peppers with EDB. Hence, no tolerance has been established. The inorganic bromide residue obtained from peppers following fumigation with 8 g EDB/m^3 at 15°C ± 2°C (0.5 lb/1,000 ft^3 at 59°F ± 3.5°F) ranged from 19 to 22 p/m.

Discussion and Conclusions

Our data led us to the conclusion that MB is not a suitable fumigant for green bell peppers because dosages that reportedly kill the Mediterranean fruit fly severely injure the peppers. Recently, an MB treatment for bell peppers, "adequate to destroy the Mediterranean fruit fly," was published in the Federal Register (*17*). This treatment consists of fumigation with MB at 32 g/m^3 for 3.5 hr at 21°C (3.0 lb/1,000 ft^3 at 70°F) or above and includes a note of warning that bell peppers are "marginally tolerant" to MB fumigation. However, the results of our tests show that bell peppers are nontolerant to MB fumigation at such treatment levels.

In contrast, EDB at 8 g/m^3 applied for 2 hr at 15°C (0.5 lb/1,000 ft^3 at 59°F) appears to be a suitable treatment for peppers when circumstances demand that they be fumigated. A slightly higher dosage (10 g for 2 hr EDB/m^3) is an approved quarantine treatment for the Mediterranean fruit fly with citrus fruits that are between 15.5 and 20.5°C (*15*, sec. VI, p. 7); however, no such treatment has been approved as efficacious for green bell peppers. Aeration time does not appear to be critical for this dose and temperature, as long as it is no less than 2 hr. Temperature during fumigation must be carefully controlled, however, since the dosage we used was minimally phytotoxic at 15°C but may be more toxic at higher temperatures, as suggested by the results of Pratt et al. (*10*).

Our data led us to suggest that an inorganic bromide residue tolerance of 30 p/m (equal to that for MB-treated peppers) be established for peppers treated with EDB, should the treatment we used prove to be effective against the Mediterranean fruit fly. Such a treatment would provide an alternative to the currently approved quarantine treatment in which the peppers are exposed to heated water vapor, a procedure to which the peppers are only marginally tolerant (*15*, sec. VI, p. 18).

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